General Study Approach

2.1 The Cost Question

In calculating unbundled network element costs, Southwestern Bell cost analysts answer the following question:

> *What are the forward-looking, long run incremental costs for a network element recognizing Southwestern Bell's existing network and using forward-looking, efficient technologies, with network maintenance and operations reflecting these technologies?*

The cost analyst calculates the cost to provide an unbundled local loop, a minute of use on a local switch or other network element, not based on existing plant, investment and operating expenses, but rather using forward-looking design for local loop facilities, all digital switching, and other plant.

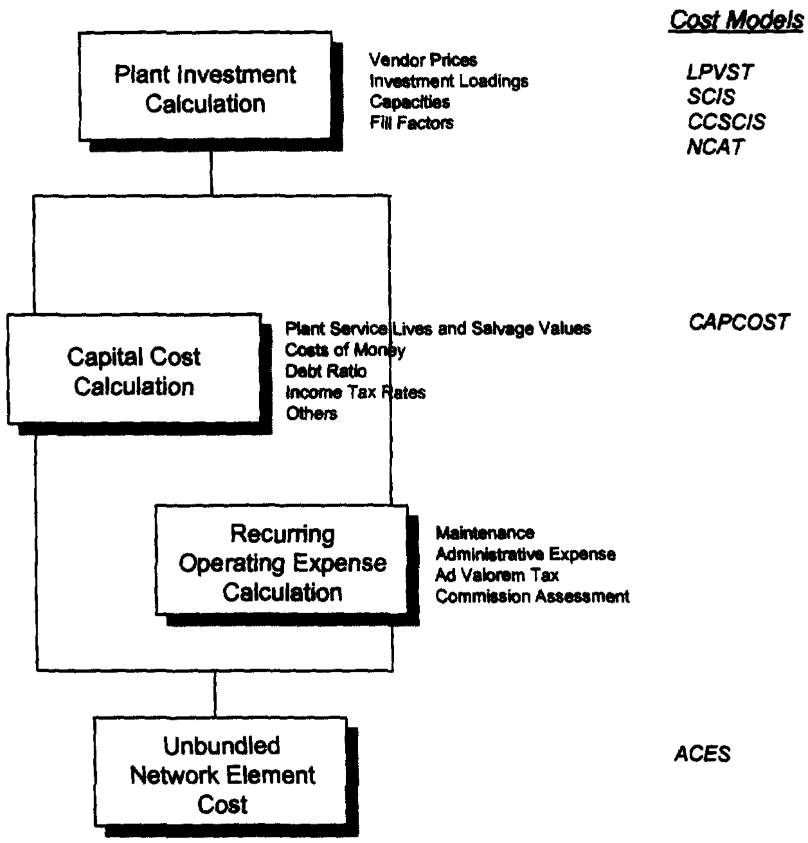
The cost analyst computes these forward-looking plant costs reflecting current vendor prices and discounts for equipment, current engineering and labor costs, etc. Plant maintenance and other operations reflect systems and procedures associated with these forward-looking technologies. In summary, unbundled network element costs reflect a forward-looking network operation designed to satisfy total demand, yet reflective of the way the network has evolved, particularly with regard to wire center locations.

Costs computed in this way are referred to as total element long run incremental costs (TELRIC). It is important to recognize that TELRIC is a special case of incremental costs. Incremental costs typically reflect differences in future plant costs and operating expenses due to relatively small differences in demand caused by introducing a new service or changing an existing service offering. TELRIC is the incremental cost of the total demand for a network element.

2.2 Study Flow

The general flow of the cost study is shown in Figure 2.1. The first step is to calculate the *plant investment per unit of a network element.*

Figure 2.1



The plant investment required to provide a network element consists of several (perhaps many) plant components. For example, the plant necessary for an unbundled local loop consists of parts of the main distributing frame in the central office, distribution and feeder cables, feeder-distribution interfaces, premises terminating equipment and others. Plant investments are computed for each component reflecting the mix of equipment used today to provide the component, appropriate equipment quantities, vendor prices, capitalized engineering and labor costs, support assets (such as power equipment and buildings) and others.

Plant investments per unit of a network element are then computed by dividing the plant investment necessary for each component by its *expected capacity utilization.* Expected capacity utilization is simply the *physical capacity* of the plant component multiplied by its *fill factor* or *utilization.* This gives a measure of the amount of investment which would be required using forward-looking technologies to provide a network element.

In the second step, *annual capital costs* are calculated. These include *depreciation expense* for the recovery of plant investment over its service life, a return requirement or *cost of money* associated with investor-supplied capital used to construct the plant, and an *income tax* obligation associated with the equity portion of the cost of money. Southwestern Bell computes capital costs using a model called CAPCOST.

Network element costs also include *recurring operating expenses* associated with the maintenance of plant, network administration functions, support assets, miscellaneous other operating taxes and a commission assessment on revenues received in providing network elements to other carriers. Operating expenses are computed using various expense factors which are unique to each type of plant, recognizing different levels of maintenance and network administration necessary for different plant types. Network element costs then are the sum of the recurring capital costs and operating expenses associated with the plant required to provide the network element.

In the Sections 3 - 6, the unbundled loop, end office switching, transport and operator services cost studies are described. The same general approach for computing network element costs is followed, although the study methods and procedures are adapted to the specific requirements of each study. Section 7 provides an overview of the other network element cost studies.

Unbundled Loop Costs

3.1 Study Purpose

The Unbundled Loop Cost Study calculates the cost to Southwestern Bell to provide an unbundled loop assuming a local network based on forward-looking plant technologies and costs of plant construction. A loop consists of the telephone plant from the *network interface device* at a customer's premises to the serving central office of Southwestern Bell. Loop costs are calculated for the following types of loops.

- *8db Loop.* A basic "two-wire" loop suitable for regular voice telephone service. Costs also are calculated for a four-wire loop.
- *Basic Rate Interface (BRI) Loop.* An Integrated Services Digital Network (ISDN) loop.
- *DS1 Loop.* A transmission path from the customer premises to the serving wire center capable of conveying digital signals of 1.544 megabits per second.

For each type of loop, costs are computed for three geographic zones corresponding with rural, mid-size and large, urban wire centers. Loop costs vary among the geographic zones due to differences in loop length, cable mixes and sizes, and other factors which vary among the zones.

Loop costs are expressed as a *recurring monthly cost* which includes capital costs (depreciation, the cost of money and income taxes) and operating expenses for ongoing plant maintenance, network administration and other activities. Non-recurring costs are computed for the activities necessary to provision unbundled loops and are distinguished for the first or initial unbundled loop versus additional loops. Figure 3.1 illustrates the costs calculated in the unbundled loop cost study.

In this document, the calculation of 8db two-wire loop costs is described, as well as the non-recurring provisioning costs for the 8db loop. For details on the other loop costs refer to the Unbundled Local Loop Study documentation in each state.

Figure 3.1

Unbundled Loop Cost Study Results

Loop Recurring and Non-Recurring Costs

Type of Loop	Geographic Zone	Recurring Cost	Non-Recurring Cost Initial	Non-Recurring Cost Additional
8db Loop	1	$XX.XX	$XX.XX	$XX.XX
	2	$XX.XX	$XX.XX	$XX.XX
	3	$XX.XX	$XX.XX	$XX.XX
BRI Loop	1	$XX.XX	$XX.XX	$XX.XX
	2	$XX.XX	$XX.XX	$XX.XX
	3	$XX.XX	$XX.XX	$XX.XX
DS1 Loop	1	$XX.XX	$XX.XX	$XX.XX
	2	$XX.XX	$XX.XX	$XX.XX
	3	$XX.XX	$XX.XX	$XX.XX

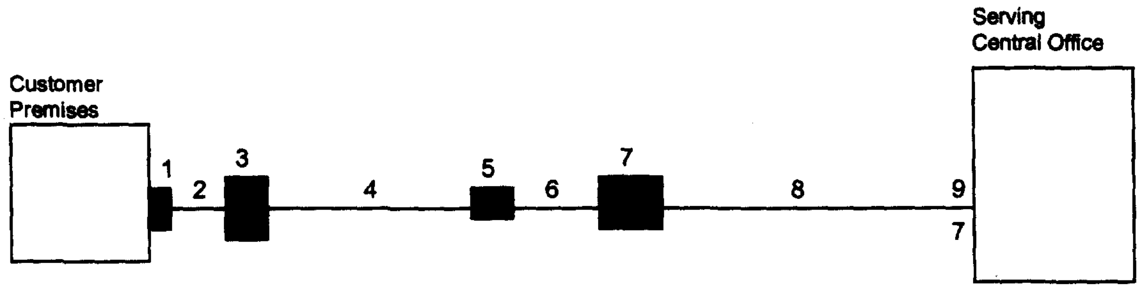
3.2 Loop Components

An 8db loop includes Southwestern Bell plant from the customer premises, through distribution and feeder cable facilities, to the main distributing frame in the serving central office. Figure 3.2 illustrates the components of an 8db loop.

- *NID, Drop Cable and Terminal.* The network interface device (NID), drop cable and terminal are referred to as *premises termination equipment* in the loop cost study. They provide the transmission path from the last cable spice in the outside plant network to the customer's premises. The 8db loop cost study recognizes two possible configurations of premises termination - one involving a singe pair of wires to the customer premises, and the other two pairs. A weighted average of costs for the two configurations is used in the study.

- *Distribution Cable.* The copper cable which runs from the feeder-distribution interface to the terminal located near the customers premises. *The feeder-distribution interface* is the "cross-connection" point between the feeder cable from the serving central office and the distribution cable. A mix of aerial, buried and underground cables is used in the study. The cable mix varies by geographic zone. Pole and conduit investment to support distribution cable also are included in the loop cost calculation.

Figure 3.2



1. Network Interface Device
2. Drop Cable
3. Terminal
4. Distribution Cable
5. Feeder-Distribution Interface
6. Feeder Stub
7. Digital Loop Carrier System
8. Feeder Cable
9. Main Distributing Frame Stringer

- *Feeder Stub and Digital Loop Carrier (DLC) System.* When loop feeder cable lengths exceed a certain threshold (typically 15,000 feet), fiber feeder cable and digital loop carrier systems are used in the cost study as the most efficient loop design. In this case a feeder stub or section of cable is required to connect the feeder cable to the DLC equipment.

  The digital loop carrier system requires circuit equipment located in the field. Approximately 75% of the time circuit equipment is required at the central office as well. The DLC equipment provides multiplexing of voice channels over the fiber cable between the serving central office and the feeder-distribution interface. The study assumes three system sizes with 192, 672 and 1,344 channels of capacity. The amount of DLC investment per loop depends upon the frequency of fiber versus copper feeder, the percentage of integrated DLC systems (which do not require central office terminating equipment), system size and expected utilization of the system (fill factor).

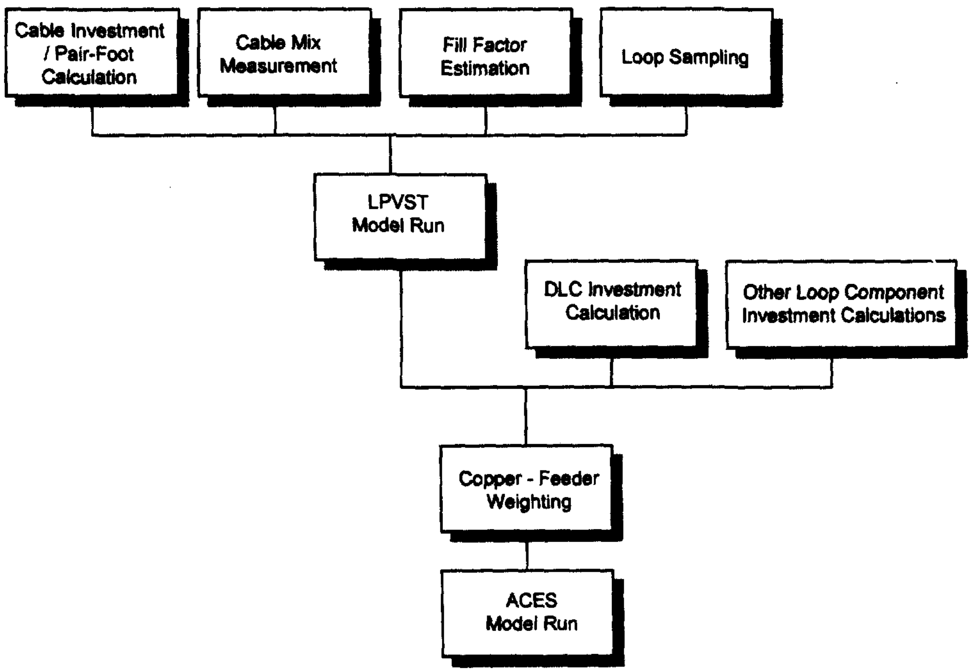
- *Feeder Cable.* Copper or fiber cable running from the serving central office to the feeder-distribution interface or remote DLC terminal. The cost study reflects a mix of aerial, buried and underground cables depending upon the geographic zone. Copper feeder is assumed for loops with feeder cable lengths less than 15,000 feet. As with distribution cable, pole and conduit plant investment is included in the loop cost calculation.

- *Frame Stringer.* Equipment connecting outside plant cables to the Main Distributing Frame. Includes a protector unit, protector block, riser cable and the labor cost to place the equipment.

3.3 Study Flow - Recurring Monthly Costs

As described earlier, loop costs include the *recurring monthly costs* Southwestern Bell incurs in providing loops and the *non-recurring costs* to provision the loop. In this section, the study flow for computing recurring monthly costs is described. The study flow is illustrated in Figure 3.3.

Figure 3.3



The loop cost study uses several interrelated models and special studies. LPVST is the primary model in the study. It is used to compute *the plant investment per loop for the distribution and feeder cable components* of the loop. Plant investments are computed for the three geographic zones based on loop characteristics in each zone. These characteristics include:

- *Loop length.* Samples of actual loops in service are used to determine average loop lengths in zones 1, 2 and 3. (See Section 3.4.)

- *Mix of cable types.* Different proportions of aerial, buried and underground cable are used in rural, mid-sized and urban wire centers. These are based on a study of cable types in service. (See Section 3.6.)

- *Installed cable costs per pair-foot* by cable type and wire gauge (26, 24, 22, and 19 gauge). Installed cable costs vary depending on the size of cable in terms of pairs per cable. Calculations are made to determine the mix of cable sizes, and based on this mix installed cable costs per pair-foot are determined for each combination of cable type and wire gauge. (See Section 3.5.)

- *Fill factors.* Other calculations are made to determine actual utilization levels for copper distribution cables, copper feeder cables and fiber feeder cables. (See Section 3.7.)

These characteristics are measured for the existing local facilities network. Adjustments then can be made if characteristics are expected to be different in the future. LPVST also determines investments in poles and conduit structures per loop based upon investment loading factors (See Section 9.)

In parallel with the calculation of distribution and feeder cable investments per loop, the investments in digital loop carrier systems and the other loop components are computed. The latter includes the premises termination equipment, feeder-distribution interface, feeder stub, and main distributing frame stringer. Each of these additional loop investments is calculated using a special study made by a cost analyst with input from subject matter experts in engineering.

3.4 Loop Samples

Loop length is a key driver of loop costs ... the longer the loop, the more plant investment is required. Since the object of the unbundled loop cost study is to determine the forward-looking cost to serve the total demand for loops, *average loop lengths* must be estimated for all loops in each geographic area.

Rather than measure the lengths of all loops, a representative sample is taken at random. In random sampling, the number of samples which must be taken to accurately measure the average of the population depends on several factors:

- *Variability.* The more loop lengths vary within a study area, the greater the chance the average loop length of a sample is significantly different than the true average. Sample sizes must be larger when loop lengths vary significantly. On the other hand, geographic areas which have less variance in loop lengths require smaller samples. Small sample sizes often provide very good estimates of the true average.

- *Confidence Interval.* When a sample is taken and the average loop length is computed, some assurance is needed that the true average is within a reasonable range around the sample average. Typically, a 95% confidence interval is used. This means the cost analyst can assume there is a 95% chance the true average is within this range. The confidence interval can be "tightened" to a satisfactory range by increasing the sample size.

- *Size of the Population.* The larger the population of loops the greater the chance a random sample will be representative. In Southwestern Bell studies loop populations typically number in the hundreds of thousands.

The sampling techniques used by Southwestern Bell determine proper sample sizes. Samples are taken at random from the Loop Engineering Information System (LEIS) database which maintains records of lines in service. The system records actual lengths of feeder cables and provides estimates of distribution cable lengths. Once a valid sample of several hundred loop lengths is obtained, the data are entered in the LPVST model to compute average feeder and distribution cable investments per loop.

3.5 Cable Investment / Pair-Foot

Cable costs are measured by linear foot and vary by *cable type, wire gauge* and *cable size*. For example, assume a foot of buried cable with 26 gauge wire in a 200 pair cable size has a installed cost of approximately $5.00. This figure includes the cable material, telco engineering and labor, miscellaneous materials and contractor charges for placing the cable. Similarly, assume 26 gauge, 300 pair buried cable costs about $1.00 more per foot, or $6.00.[4]

Loop cable plant is made up of numerous sections of cable of various cable type, wire gauge and cable size. To calculate loop investments it is necessary first to compute a cable cost for the mix of cable sizes in a geographic zone. This figure is expressed as an *cable investment / pair-foot of cable capacity.* Separate investments / pair-foot are computed for each cable type and wire gauge. These *unit investments* are applied to the average loop lengths from the loop samples to compute loop investments.

In the example above, the first 26 gauge buried cable requires an investment of $0.0250 per pair-foot, and the second cable $0.0200 per pair-foot. A unit investment for 26 gauge buried cable in each geographic zone is computed based on the weighted average of these and other cable sizes in the zone. This average reflects both *feeder* and *distribution* cables.

Since feeder cables tend to be larger than distribution cables, the cable cost per pair-foot for feeder cable is less than the cost of distribution cable. To reflect this difference, the unit investment for feeder and distribution cables combined is "deaveraged" between feeder and distribution cables. This is done in two steps. For example, the unit investment for *buried feeder cable* is calculated based on records of feeder cable sizes and quantities. Then, the unit investment for distribution cable is "solved for" based on the unit investment for feeder and distribution cables combined, the feeder unit investment and the relative proportion of feeder and distribution cable lengths in a geographic zone. Figure 3.4 illustrates the level of detail of cable unit investments for each of three geographic zones.

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[4] Cable costs are obtained from Southwestern Bell Engineering's records of current outside plant construction cost data. These data are used by engineers in planning current outside plant construction projects. Cable costs are adjusted to reflect any change in cable cost anticipated in the near future.

Figure 3.4

Geographic Zone

Copper Feeder Cable

	Wire Gauge			
Cable Type	26	24	22	19
Aerial Cable	$0.XXX	$0.XXX	$0.XXX	$0.XXX
Buried Cable	$0.XXX	$0.XXX	$0.XXX	$0.XXX
Underground Cable	$0.XXX	$0.XXX	$0.XXX	$0.XXX

Copper Distribution Cable

	Wire Gauge			
Cable Type	26	24	22	19
Aerial Cable	$0.XXX	$0.XXX	$0.XXX	$0.XXX
Buried Cable	$0.XXX	$0.XXX	$0.XXX	$0.XXX
Underground Cable	$0.XXX	$0.XXX	$0.XXX	$0.XXX

Fiber cable investments / pair-foot are computed for buried and underground cables. First, fiber costs per foot are obtained from Engineering's cable construction cost data. The cable sizes used in the study are 24 fiber cable for zone one, 48 fiber cable in zone 2, and 144 fiber cable in zone 3. Contractor placement costs and innerduct costs (for underground cable) are added. The total installed cost per foot for each cable size then is divided by the number of fibers per cable (24, 48 or 144) to compute the installed cost / fiber-foot.

Four fibers are assumed for each DLC system. Consequently, the installed cost / fiber-foot for each cable size is multiplied by four fibers to compute the installed cost / foot and DLC system. This figure is divided by the voice grade channel capacity of the DLC systems to arrive at fiber cable investments / pair-foot.

3.6 Cable Mix Measurement

The relative proportions or mix of cable types (*percentages of aerial, buried and underground cables*) for loop distribution and feeder cable in the geographic zones is determined by measuring in-service quantities (total cable sheath-feet) of each cable type. Two measurements are required. The first measurement reflects feeder and distribution cable combined. A second measurement is made of only feeder cable. The total feeder cable sheath-feet is subtracted from the total cable sheath-feet to determine the distribution cable in-service quantity. Cable mixes are separately computed for distribution and feeder cables by zone based on the resulting quantities of each cable type.

3.7 Fill Factor Estimation

Fill factors are based on actual plant utilization. A separate fill factor is calculated for feeder cable, distribution cable and DLC systems. The cable factors are computed by dividing the number of working pairs by the number of available and spare pairs in each cable route. The DLC fill factor is based upon actual DLC channel utilization.

3.8 LPVST Model

LPVST is a cost model used to compute forward-looking loop plant investments. It was developed many years ago by the Bell System and is now maintained by Southwestern Bell. The model relies on the cost data described in Sections 3.4 - 3.7. These data include loop lengths divided between distribution and feeder cable for a sample of loops in each geographic zone, cable investments / pair-foot of capacity, cable mixes and fill factors. Two additional input items - pole and conduit plant investment factors - also are used in LPVST to compute the investment in structures required to support cables.

To calculate *loop plant investments for distribution and feeder cable* by geographic zone the following steps are used by LPVST.

- *Frequency distribution of loop lengths.* The distribution and feeder cable lengths for each loop sample are assigned to a "mileage band" based on the distribution and feeder cable measurements provided by the LEIS data base. The mileage bands are in 1,000' increments, beginning with 0 - 1,000', 1,000 - 2,000', and so on. A loop with a distribution cable length of, say, 5,542' would fall in the 6,000' mileage band, and a loop with 4,420' of distribution cable would be in the 4,000' mileage band. (The dividing point between bands is the mid-point; loop lengths are rounded to the nearest band.) By assigning each loop to one of the mileage bands, the *frequency distribution* of loop lengths is determined. It shows the percentage of loops in a geographic zone which are expected to fall in each mileage band.

- *Distinction of loops with copper and fiber feeder cable.* Loops with feeder cables above and below the copper - fiber cutover point (15,000') are separated. Therefore, for each geographic zone there actually are three frequency distributions - one for the distribution cable portion of loop length, another for the feeder cable portion of the loop when the loop design calls for copper feeder cable, and the third for the feeder cable portion of the loop when fiber cable is used. The three distributions, in effect, are used to compute average lengths of distribution cable, copper feeder cable and fiber feeder cable.

- *Mix of wire gauge.* LPVST also distinguishes the mix of wire gauges for copper distribution and feeder cables. Since the electrical resistance in copper wire increases with length, LPVST contains tables which indicate the maximum distance at which the smallest gauge wire (26 gauge) can be used, at which point the next size wire (24 gauge) is used until its limit is reached, followed by 22 gauge and then 19 gauge wires. Thus, LPVST estimates the average length and mix of wire gauges for copper distribution and feeder cables in rural, mid-sized and urban wire centers.[5]

- *Mix of cable types.* In the proceeding steps, LPVST computes average copper distribution and feeder lengths by wire gauge, and an average fiber feeder cable length. Since the cables are a mix of aerial, buried and underground cable, the next step is to apply the percentages of each cable type to the average lengths. These percentages vary for copper distribution, copper feeder and fiber feeder cables.

- *Cable investments / pair-foot in service.* Section 3.5 described the special study used to compute cable investments / pair-foot of *capacity* for each cable type. Because not all cable pairs will be in service, it is necessary to adjust the cable unit investments to reflect expected utilization. This is done by dividing the unit investment for each cable type by the fill factor. (See Section 3.7.) This calculation yields an amount equal to the cable investment / pair-foot *in service.*

- *Loop investments.* The cable investments / pair-foot in service then are applied to the average cable lengths to determine the investment in distribution and feeder cables in each geographic zone.

- *Structures investment.* In addition to the investment in cable, loops also require investment for poles and conduit. These investments are calculated by applying ratios of structure investment to cable investment to the aerial and underground cable portions of loop investment. This step completes the LPVST investment calculations, and the results are carried forward to be summarized with the digital loop carrier and other loop component investments described in Sections 3.9 and 3.10.

3.9 Digital Loop Carrier Investment

Digital loop carrier (DLC) systems are assumed for loops with *feeder cable lengths* above a certain threshold - typically 15,000 feet. A DLC system consists of digital electronic circuit equipment which enables many voice channels to be combined over the same fiber. This is accomplished using "time-division multiplexing." The result is lower costs and better transmission than traditional copper cables for loops with long feeder cable lengths.

Three sizes of DLC systems are used in the unbundled loop cost study. The smallest system has a capacity of 192 voice channels and is used in the rural

[5] Gauge measurements do not apply to *fiber* feeder cable. In this case, LPVST simply determines average feeder cable length for loops with feeder cable exceeding the 15,000' threshold for fiber cable.

geographic zone. The second system has 692 channels of capacity and is used in the mid-size geographic zone. The third system handles up to 1,344 channels in the urban zone.

One of the key factors underlying DLC costs is whether the system is "integrated" with the serving end office. An integrated DLC system is connected directly to the switching system such that digital signals from subscribers do not have to be "demultiplexed" and converted to analog signals. This saves from having to have *central office terminating equipment* for the DLC system. Non-integrated DLC systems require central office terminating equipment to demultiplex signals and covert them to analog signals as they were before entering the DLC system. In both cases, DLC equipment, called *remote terminating equipment,* is required in the field. The unbundled loop cost study calculates DLC investment per loop reflecting a relative frequency of integrated and non-integrated systems.

DLC investments are computed in a special study which identifies the equipment components, quantities, current material prices and engineering and labor to construct the three sizes of DLC system. DLC investments per loop are calculated by dividing the DLC investments by the expected channel utilization for each system. The latter is computed by dividing the physical capacity of each system (192, 672 or 1,344 voice channels) by the DLC system fill factor. This factor reflects the expected utilization of the system.

3.10 Other Loop Components

The investments in distribution and feeder cables and the digital loop carrier system typically represent 90% or more of the investment in loop plant. There are several other important loop components included in the study. These are illustrated in Figure 3.2 and described below:

- *Premises termination equipment (NID, drop cable and terminal).* An 8db loop requires a single premises termination with a one or two pair drop cable. Investments are computed for one and two pair drop cables and weighted based upon the frequency of each. Premises termination investment includes the equipment costs of the network interface device, drop cable and terminal, as well as labor costs for installing the equipment and cable splicing. Cost data are from Engineering's outside plant construction cost data.

- *Feeder distribution interface (FDI).* The FDI investment represents the cost of the cabinet and equipment providing the cross-connect point between the feeder and distribution cables. FDI investment per loop is computed based on an analysis of the number of FDI boxes of various line sizes and the installed costs of each.

- *Feeder stub.* The feeder stub investment is calculated based on an average feeder stub length derived from a random sample and the installed cost /

pair-foot for feeder stub cable. The unit investment for the stub cable is divided by the fiber feeder cable fill factor to allow for the cost of spare capacity in the feeder stub.

- *Main distributing frame stringer.* Frame stringer investments include the costs of a protector unit and protector block, the riser cable connecting the outside plant cable to the main distributing frame, and installation labor. Investments are calculated for copper feeder cables and fiber feeder cables. Unit investments are increased by the copper or fiber feeder cable fill factors to recognize the costs of spare frame stringer equipment.

After these special studies for the other loop components are completed, loop investments are summarized for each geographic zone on a "loop spreadsheet" Figure 3.4 illustrates the type of cost information which is contained. Note that the investments for copper and fiber feeder cables, the DLC system and the feeder stub are multiplied times a frequency factor to reflect the percentage of loops which are provided using these components. The primary purpose of the loop spreadsheet is to summarize loop investment by account so that capital cost and operating expense factors can be applied to the investments in ACES to calculate recurring monthly costs.

Figure 3.4

Geographic Zone

Loop Component	Frequency	Copper Aerial Cable	Copper Buried Cable	Copper Underground Cable	Fiber Buried Cable	Fiber Underground Cable	Poles	Conduit	Circuit Equipment	COE Frame
Premises Termination	100%	$XX.XX	$XX.XX							
Distribution Cable	100%	$XX.XX	$XX.XX	$XX.XX			$XX.XX	$XX.XX		
Feeder - Distribution Interface	YY%		$XX.XX							
Feeder Cable										
Copper	XX%	$XX.XX	$XX.XX	$XX.XX			$XX.XX	$XX.XX		
Fiber	YY%				$XX.XX	$XX.XX	$XX.XX	$XX.XX		
Feeder Stub	YY%		$XX.XX							
DLC System	YY%								$XX.XX	
MDF Stringer	100%									$XX.XX
		$XX.XX	$XX.XX	$XX.XX	$XX.XX	$XX.XX	$XX.XX	$XX.XX	$XX.XX	$XX.XX

Note: XX% + YY% = 100%

3.11 Automated Cost Extraction System (ACES)

ACES has two purposes. The first is to add additional capitalized costs for sales taxes, telco engineering and labor, miscellaneous materials, power equipment and buildings to house equipment, if these amounts have not already been included in previous calculations. Secondly, ACES computes recurring monthly capital costs and operating expenses based on plant investments for the network elements. These computations are based on capital cost and operating expense factors entered in ACES. (See Sections 8, 9 and 10.)

The calculations performed by ACES are straightforward as illustrated by the examples of the two pages of ACES output shown in Figures 3.5 and 3.6. The first page shows input cost data. There is one page for each plant account to allow for differences in depreciation rates, equipment maintenance and other cost factors which vary among types of plant.

- *Total Equipment Investment.* This is the amount of investment by plant account necessary to provide a unit of demand for the network element, such as an unbundled loop. The figure is from the LPVST model or one of the other component investment studies.

- *Investment Loadings.* Lines 2 - 12 contain factors used to compute the additional costs of construction for telco engineering and labor, power equipment, etc. Some of these values will be zero if they do not apply or have already been included in the investment calculations.

- *Capital Cost Data.* Lines 14 - 16 provide the factors which are multiplied times the network element investments to compute annual capital costs - depreciation, the cost of money and income taxes. The factors are calculated in the CAPCOST model based on plant service lives, net salvages, the cost of money, the debt ratio, income tax rate and other factors. The ACES input sheet also shows inflation factors for capital costs and operating expenses. The capital cost inflation factor is used to inflate (or possibly deflate) the current investment and related capital costs to reflect a *future planning period.*

- *Annual Expense Data.* Lines 18 - 22 contain factors used to compute recurring operating expenses. The first four factors are multiplied times the network element investment to compute recurring annual expenses. The maintenance factors determine expenses for plant maintenance, and depending on the plant type may include expenses for testing and power. The administrative expense factor includes various network administration, engineering and support asset expenses. The ad valorem tax factor captures the cost of taxes levied on the value of plant. And finally, the commission assessment factor is used to "gross-up" the subtotal of the preceding capital costs and operating expenses to calculate the taxes charged on revenues received in providing network elements. *Operating expense factors exclude any retail marketing expenses.*

The second page of ACES output shown in Figure 3.6 shows the calculations of the additional investment amounts, capital costs and operating expenses. Each line of calculations is clearly described on the output page.

Output from ACES consists of an annual cost figure for each plant account. These are summed and simply divided by 12 months per year to compute the monthly loop costs shown in Figure 3.1. This completes the study for the recurring monthly costs of an unbundled loop.

Figure 3.5 - ***Illustrative***

To Schedule A
02/19/97

STATE - 1997
TEST STUDY
INPUTS SHEET
TEST INVESTMENT

97- -UCS-7821 V2.1
EQUIPMENT INVESTMENT:

	(Input)	(TPI)	(Weight Factor)		
	1000	* 1.000000	* 1.000000	=	$1,000.00

1.	EQUIPMENT INVESTMENT (EF&I)			$1000.00	
2.	RATIO OF MATERIAL TO TOTAL EF&I			0.85000	
3.	SALES TAX		0.050000	$42.50	8/30/96
4.	TOTAL EF&I INVESTMENT (EF&I)			$1042.50	8/30/96
5.	TELCO Engineering		0.030000	$31.28	8/30/96
6.	TELCO Plant Labor		0.050000	$52.13	8/30/96
7.	Sundry & Miscellaneous		0.010000	$10.43	8/30/96
8.	Total Installed Cost			$1136.34	8/30/96
9.	Power Investment		0.080000	$90.91	8/30/96
10.	Total Equipment Investment			$1227.25	8/30/96
11.	Total Unit Investment With Fill		1.000000	$1227.25	8/30/96
12.	Building Investment Per Unit		0.460000	$564.54	8/30/96
13.	Total Unit Investment			$1791.79	8/30/96
	ANNUAL CAPITAL COSTS				
14.	DEPRECIATION	- Equipment (Inf * 0.1077)	0.110000		
		- Building (Inf * 0.0294)	0.030000	$151.93	8/30/96
15.	COST OF MONEY	- Equipment (Inf * 0.0489)	0.050000		
		- Building (Inf * 0.0783)	0.080000	$106.53	8/30/96
16.	INCOME TAX	- Equipment (Inf * 0.0196)	0.020000		
		- Building (Inf * 0.0294)	0.030000	$41.48	8/30/96
17.	TOTAL ANNUAL CAPITAL COSTS			$299.94	
	ANNUAL OPERATING EXPENSE				
18.	EQUIPMENT MAINTENANCE	(OEInf * 0.0843)	0.090000	$110.45	8/30/96
19.	BUILDING & GROUNDS MAINTENANCE	(OEInf * 0.0094)	0.010000	$5.65	8/30/96
20.	ADMINISTRATION EXPENSE	(OEInf * 0.0375)	0.040000	$71.67	8/30/96
21.	AD VALOREM TAXES		0.020000	$35.84	8/30/96
22.	COMMISSION ASSESSMENT		0.010000	$5.24	8/30/96

*	Inf	Capital Cost Inflation Factor	97-99	1.0217
*	OEInf	Operation Expense Inflaction Facto	97-99	1.0674

Figure 3.6 - ***Illustrative***

Schedule A
02/19/97

STATE - 1997
TEST STUDY
RECURRING COST
TEST INVESTMENT

97- -UCS-7821 V2.1
EQUIPMENT INVESTMENT:

1.	EQUIPMENT INVESTMENT (EF&I)			$1000.00
2.	RATIO OF MATERIAL TO TOTAL EF&I			0.85000
3.	SALES TAX	((L1*L2)*	0.050000)	$42.50
4.	TOTAL EF&I INVESTMENT (EF&I)	(L1+L3)		$1042.50
5.	TELCO Engineering	(L4*	0.030000)	$31.28
6.	TELCO Plant Labor	(L4*	0.050000)	$52.13
7.	Sundry & Miscellaneous	(L4*	0.010000)	$10.43
8.	Total Installed Cost	(L4+L5+L6+L7)		$1136.34
9.	Power Investment	(L8*	0.080000)	$90.91
10.	Total Equipment Investment	(L8+L9)		$1227.25
11.	Total Unit Investment With Fill	(L10/	1.000000)	$1227.25
12.	Building Investment Per Unit	(L11*	0.460000)	$564.54
13.	Total Unit Investment	(L11+L12)		$1791.79
	ANNUAL CAPITAL COSTS			
14.	DEPRECIATION	(L11*	0.110000)	
		+(L12*	0.030000)	$151.93
15.	COST OF MONEY	(L11*	0.050000)	
		+(L12*	0.080000)	$106.53
16.	INCOME TAX	(L11*	0.020000)	
		+(L12*	0.030000)	$41.48
17.	TOTAL ANNUAL CAPITAL COSTS	(L14+L15+L16)		$299.94
	ANNUAL OPERATING EXPENSE			
18.	EQUIPMENT MAINTENANCE	(L11*	0.090000)	$110.45
19.	BUILDING & GROUNDS MAINTENANCE	(L12*	0.010000)	$5.65
20.	ADMINISTRATION EXPENSE	(L13*	0.040000)	$71.67
21.	AD VALOREM TAXES	(L13*	0.020000)	$35.84
22.	COMMISSION ASSESSMENT	(SUM(L17..L21)*	0.010000)	$5.24
23.	TOTAL ANNUAL OPERATING EXPENSES	SUM(L18..L22)		$228.85
24.	TOTAL ANNUAL COST PER UNIT	(L17+L23)		$528.79
25.	TOTAL MONTHLY COST PER UNIT	(L24/12)		$44.07

3.12 Non-Recurring Costs

The non-recurring costs in the loop studies are for activities involved in provisioning an unbundled loop (service activation) and disconnecting the loop when service is discontinued. Non-recurring costs are computed for the initial loop on an order and for additional loops after the first. Two work groups are involved in the provisioning process:

- *Circuit Provisioning Center.* This group performs several administrative activities related to provisioning an unbundled loop. The group also performs administrative activities when service is discontinued.

- *Installation & Maintenance (I&M).* The I&M group performs the actual field work for the unbundled loop. Activities include travel, running cross-connects, performing tests and order completion. Activity times are weighted by the percentage of loops which are expected to require field work.

To compute non-recurring costs the activity times for each work group are multiplied by a directly assigned labor rate which include salaries and wages, benefits, direct supervision and other costs directly attributable to an hour of productive labor.

3.13 Other Loop Costs

In addition to the 8dB loop, monthly costs are computed for basic rate interface (BRI), DS1 and four-wire loops. The study methodologies are similar to the methodology used in the 8dB loop cost study, although cost data are unique to these types of loops. For details on these cost studies, refer to the documentation titled Unbundled Local Loop Study and Unbundled Four-Wire Local Loop Cost Study.

Cost studies also have been completed for the non-recurring costs of work associated with the Network Interface Device at a customers premises and the additional costs of loss conditioning for an 8db loop. Documentation is provided for each of these studies.

Finally, the Network Component Cross-Connect cost study computes the costs of materials and labor necessary to make a physical connection from Southwestern Bell's main distributing frame or other equipment in a central office to equipment owned by an interconnecting carrier. There are several types of cross-connects included in the study.

End Office Switching Costs

4.1 Study Purpose

There are two primary studies for end office switching network element costs.[6] *The end office usage* cost study determines the cost to Southwestern Bell to provide a *minute of use* of local or toll calling on a local switching system based on forward-looking digital switching technologies. *The end office analog line-side port* cost study computes the monthly cost to terminate a subscriber access line on the same digital switching systems.

End office usage costs are calculated for *three geographic zones* corresponding with different *exchange rate groups*. The analog line-side port cost is an average for all geographic zones and exchange rate groups. Switching systems in each zone consisted of a mix of the AT&T 5ESS, the Nortel DMS100 and the Ericcson AXE10 switches. Figure 4.1 illustrates the cost figures calculated in these two end office switching cost studies.

Figure 4.1

	Geographic Zone		
	1	2	3
Cost / Minute of Use	\$0.XXXX	\$0.XXXX	\$0.XXXX
Monthly Cost / Analog Line-Side Port	\$X.XX		

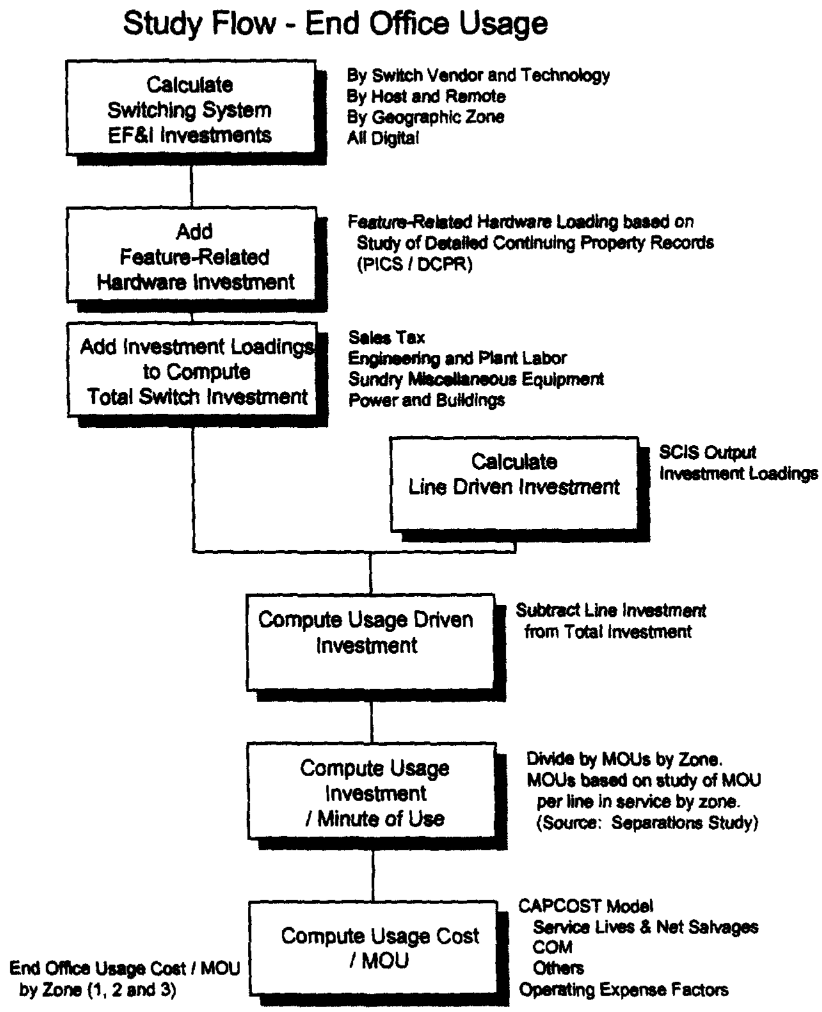
The cost / minute of use and monthly cost / analog line-side port include capital costs on the switching system investment necessary to provide each network element, as well as recurring operating expenses. Plant investment included in the study is assumed to be all digital switching. Buildings investment necessary to house digital switching systems also is included.

6 See Appendix A for a list of end office switching network elements for which costs have been computed.

4.2 Study Flow

The study flow for calculating end office usage costs is shown in Figure 4.2.

Figure 4.2



- *Switching system EF&I investments.* The first step in the study is to compute the plant investment which would be required assuming *existing digital switches* and *analog switches which are expected to be converted to digital technology in the near future* are replaced using forward-looking digital switching technologies. For example, the investment in an AT&T 5ESS digital switch placed, say, in 1991 would be recomputed as though it was being placed in service today, sized to serve existing demand and using the latest 5ESS equipment and construction costs.

Bellcore's Switching Cost Information System (SCIS) is used to compute these digital switching investments. SCIS is a well-established switching cost model used by local exchange and interexchange carriers in the U.S. and overseas. It provides valid estimates of the total investment and investments per unit of capacity of digital switching systems from each of the major switch manufacturers.

Total switch investments are computed for digital offices for each zone and switch technology.

- *Feature-related hardware and investment loadings.* Switch investments from SCIS include the costs of vendor material and engineering, furnishing and installing (EF&I) the switch at the telco central office. The investment does not include the costs of basic feature-related hardware and other construction costs, such as sales taxes, telco engineering and plant labor, miscellaneous equipment, power equipment and buildings. These costs are added subsequent to SCIS by the cost analyst or during the ACES run. (See Section 3.11 for a description of ACES.)

- *Line driven investment.* Although a switching system consists of numerous functional components, for purposes of computing network element costs the switch is divided between two categories of plant - *line driven plant* and *usage driven plant.* Line driven plant includes equipment necessary to terminate access lines. The amount of line equipment is determined by the number of lines equipped on the switch, rather than usage or the amount of calling over the lines. SCIS separately identifies line driven investment. [7] Usage driven investment for all digital switches in a geographic zone then is computed by subtracting the line investment from the total switch investment.

- *Usage investment / minute of use.* The remaining usage driven investment is for plant used to handle customer calls, provide basic features and handle various switch administrative functions. The predominant driver of switch investment is the number of minutes of use for local and toll calling originating and terminating on the switch. The usage investment in a geographic zone is divided by the annual dial equipment minutes of use for digital switches in the zone. The dial equipment minutes of use are based on minutes of use per line for switches in each zone multiplied times the number of lines in service. Minutes of use per line are determined from Separations data.

- *Usage cost / minute of use.* The final step in the study is to calculate the cost per minute of use in the three geographic zones. This is done in ACES by

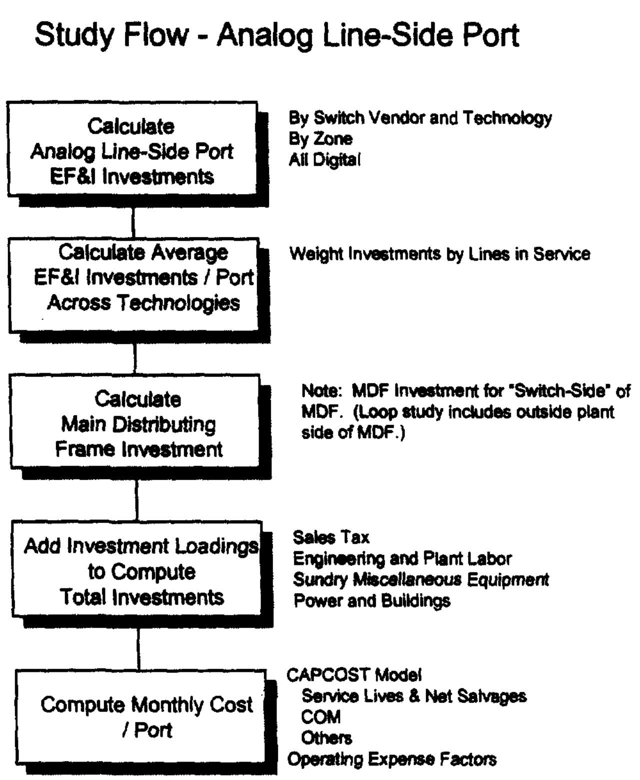
[7] SCIS output reports designate the amount of investment in each switching system which is line driven. The figure used in the cost study is called "Total Minimum Line Investment" from the total investment output report.

applying digital switching capital cost and operating expense factors to the usage investments / minute of use. Capital costs and operating expenses also are calculated for the building plant which houses the switches.

The cost study flow for the analog line-side port is similar to the end office usage cost study flow. This is shown in Figure 4.3. The study begins with the line driven investments from SCIS expressed as EF&I investments / line, rather than in terms of total line investment for a geographic zone. Since switch architectures are different among the switch manufacturers, the investments per line differ among the types of switches. For this reason, the study calculates a separate line investment for the 5ESS, DMS100, and AXE10 and then computes a weighted average based on the number of lines of each type.

A small amount of additional investment per line is added for the "switch-side" of the main distributing frame (MDF). Next, the switch line and MDF investments are entered in ACES, and additional investment amounts are added, as appropriate, for sales taxes, telco engineering and labor, miscellaneous equipment, power equipment and buildings.[8] ACES also computes the monthly capital costs and operating expenses per line based on factors from CAPCOST and the operating expense factors.

Figure 4.3



[8] See section 9 for a description of investment loadings.

In the next three sections, additional information is provided on the SCIS model, and the calculations of feature-related hardware and minutes of use per line used in the end office usage cost study.

4.3 Switching Cost Information System

Bellcore which licenses SCIS to Southwestern Bell and other telecommunications carriers describes SCIS as,

> "an interactive computer system that determines the basic switching unit resource investments of a particular type switching system. SCIS may be used to analyze the cost of a single office, or of a group of similar offices ..."[9]

SCIS models are developed for systems manufactured by several vendors, including AT&T, Northern Telecom, Ericcson and others. Switch costs are modeled for host switches, remotes and tandems.

In developing SCIS models for individual switch technologies, Bellcore selects actual switching systems representing a range of line and trunk sizes and usage characteristics. The sample switches are engineered according to the vendor's engineering rules, and switch costs are computed based on actual vendor prices. A detailed analysis of switching system equipment is performed to categorize equipment and costs in functional categories. Following this functional categorization of equipment and costs, costs per unit of capacity of each category are developed. These unit costs are representative of the model office. Unit costs then are used by SCIS to compute the costs of switching systems of different sizes and usage characteristics.

The developers of SCIS routinely test the model to assure that it accurately calculates switching system costs. These tests indicate the model produces switching system costs which are within one - two percent of costs developed using the switch manufacturer's switch provisioning models.

In addition, SCIS has been reviewed by the FCC and several state commissions over the years. In 1992 the FCC discussed its findings regarding SCIS in its Order on Open Network Architecture Tariffs of Bell Operating Companies (CC Docket No. 92-91).

> "SCIS is a forward-looking model that calculates investments based on switch replacement costs rather than historical or embedded costs, and the more recent

[9] "Bellcore Switching Cost Information System," Section 2 - Introduction, page one.

SCIS software provides the most up-to-date design and pricing basis from which to estimate future BSE-specific investments."" (para. 21)

The Commission also expressed an opinion regarding the validity of SCIS. "Andersen [independent reviewers of the SCIS model] concluded in its report that, although, SCIS permits users fairly wide discretion in selecting variables, the SCIS model itself is fundamentally sound. This finding is consistent with the findings of the Commission's review of the SCIS models submitted to us in camera in December 1991." (para 82.)

4.4 Feature-Related Hardware

Since SCIS calculates only the vendor EF&I costs for a basic switching system, it is necessary to add feature-related hardware and other construction costs to obtain the total investment in a switching system. The feature-related hardware shown in Figure 4.4 is included in the study using a feature hardware factor computed in a special study of financial records.

Figure 4.4

Equipment Item	Quantity	Investment
Conference Ports	X,XXX	$X,XXX,XXX
Class Modem Resource Cards for Calling Name Delivery	X,XXX	$X,XXX,XXX
Input / Output Ports for Simplified Message Desk Interface (SMDI)	X,XXX	$X,XXX,XXX
Power Supply for Message Waiting	X,XXX	$X,XXX,XXX
Recorded Announcement Equipment	X,XXX	$X,XXX,XXX
Tone Circuit Equipment	X,XXX	$X,XXX,XXX
Private Network Trunking Equipment (e.g., Plexar Tie Facilities)	X,XXX	$X,XXX,XXX
Data Sets or Modems for SMDI	X,XXX	$X,XXX,XXX
3A Translators for SMDI	X,XXX	$X,XXX,XXX
Total		$X,XXX,XXX
Total Associated Switching System Investment		$X,XXX,XXX
Feature Hardware Factor		XX%

Quantities and the installed cost of each equipment item are identified for the switching systems in the study from the detailed continuing property records. The total cost of feature hardware then is divided by the total EF&I investment for these switching systems to develop a percentage investment loading for feature-hardware.

The other costs of construction not included in the SCIS investments - sales taxes, telco engineering and labor, etc. - are included in the study using other investment loadings which are described in section 9.

4.5 Dial Equipment Minutes of Use

As described in section 4.2, total dial equipment minutes of use for study switches in each geographic zone are divided into the usage-driven investment for these switches to calculate end office usage investment per minute of use. The dial equipment minutes of use are computed based on *average minutes of use per line* for each zone times the number of lines in service for study switches. Figure 4.5 shows the calculations used to compute minutes of use per line.

Figure 4.5

Zone	Number of Switches	Minutes of Use Local	Minutes of Use Toll	Minutes of Use Total	Working Lines	MOU / Line
1	XX	XX,XXX,XXX	XX,XXX,XXX	XXX,XXX,XXX	XXX,XXX	X,XXX
2	XX	XX,XXX,XXX	XX,XXX,XXX	XXX,XXX,XXX	XXX,XXX	X,XXX
3	XX	XX,XXX,XXX	XX,XXX,XXX	XXX,XXX,XXX	XXX,XXX	X,XXX
Total	XX	XXX,XXX,XXX	XXX,XXX,XXX	X,XXX,XXX,XXX	X,XXX,XXX	X,XXX

4.6 Other End Office Switching Costs

In addition to usage and the analog line-side port, which are the primary end office switching network elements, there are other network elements for which costs have been computed at this time. They include the following:

- *Basic Rate Interface Port and Primary Rate Interface Port.* Basic rate interface (BRI) and primary rate interface (PRI) ports provide access to end offices for the use of Integrated Services Digital Network (ISDN) features and functions. The BRI port provides the capability for two 64 kilobit per second channels and one 16 kilobit per second channel. The PRI port provides for 23 64 kilobit per second channels and one 16 kilobit per second channel. The two ports are elements of ISDN services which can be used to provide end-users with voice and data communications. The cost study develops incremental port investments using a Bellcore ISDN model and recurring capital costs and operating expenses using ACES.

- *Two-Wire Analog Trunk Port (Direct Inward Dial).* The study determines the recurring and non-recurring costs to provide an end office trunk connection capable of providing direct inward dialing (DID). DID is a central office feature which enables incoming calls to private branch exchanges (PBXs) located on customers premises to be handled without the assistance of an attendant. Calls are routed directly to the PBX which provides answering and supervision of calls. The study determines the incremental investment and recurring monthly costs for equipment necessary to provide